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Interim Report

Survey and Analysis of Environmental Requirements for Shipboard Electronic Equipment Applications

Appendix C

Volume IV

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June 7, 1991

Dear IEEE Member,

Enclosed please find the lastest draft of the IEEE P1156.1 working group, Environmental Core Specifications and dated June 7, 1991. This has been submitted to you for your informal comments and corrections. Please check all the withstand criteria carefully.

An attempt has been made to reference all tests, including military specifications, to IEC tests where they are available. If you know of applicable IEC tests where none has been referenced please inform the committee.

If you have further questions or comments please do not hesitate to call me. Please return all comments and corrections to Rudy Schubert before July 5, 1991.

An IEEE 1156.1 Environmental Group meeting has been scheduled for Wednesday morning, July 10, 1991 at the Sun Valley site. Your participation is most welcome. If more time is needed than the morning session we can use time slots that are available for Wednesday afternoon or evening.

Sincerely,

Rudy Schubert

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PREFACE

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Comments on standards and requests for interpretations should be address to:

Secretary, IEEE Standards Board
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Statement A per Telecon
Ed Newman Naval Sea Systems Command
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NWW 9/9/91

FORWARD

(This Forward is not part of ANSI/IEEE Std 1156.1 IEEE standard for Core Environmental withstand Specifications for Microcomputers.)

With the introduction of numerous standards for computer hardware, components, circuit packs, backplanes, etc. The Microprocessor and Microcomputer Standards Subcommittee of The IEEE Computer Society found it appropriate to write a separate standard for core environmental withstand conditions for computers.

This standard provides design engineers and system engineer with requirements for core environmental withstand conditions that all components and modules used in computers should be able to withstand. These include (but are not limited to) thermal, atmospheric, shock, vibration, and corrosion during storage and operation.

At the time this document was approved, the members of the working group were:

Rudolf Schubert, Chairman
Adam J. Simonoff, Vice-Chairman

Andy Brough
Ernest Croker
Beth Montgomery
Calvin Olsen
Jack Rosenberg
Nobuaki Sugiura
Joe Trainer
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P1156.1
EVIRONMENTAL
CORE SPECIFICATIONS AND RESOURCES

1. Introduction

This standard contains fundamental information on minimum environmental withstand conditions.

It is intended to be used in those cases where a generic or detail specification for a certain component has been prepared. This standard is intended to achieve uniformity and reproducibility in the test conditions for all components which may make up larger systems that are purported to have a rated environmental performance level.

The terms "environmental withstand" or "environmental testing" cover the natural and artificial environments to which components may be exposed so that an assessment of their performance can be made under conditions of use, transport, and storage to which they may be exposed in practice. These conditions include, but are not limited to, thermal, mechanical, electrical, and atmospheric stresses.

The requirements for the performance of the components are not listed in this standard. The relevant specification for the component under test defines the minimum permissible performance limits.

A list of suggested tests for electronic equipment is given in Appendix A of IEC 512-1. Particular test sequences shall be specified in the relevant component document detail specification.

2. Scope

This specification is designed for use in conjunction with other documents such as IEEE 1101.2 (Mechanical Specification for Micro Connectors and Eurocard Form Factors), IEEE 1101.3 (Conduction Cooled Eurocard with Metric Connector), IEEE 896.2 (Futurebus+), IEEE 1596 (Scalable Coherent Interface), IEEE 1014 (VMEbus), and IEEE 1296 (Multi Bus II).

This standard is intended to be used as a core specification. It contains minimum environmental withstand conditions applicable to computer modules/circuit boards and all of their associated components. It has been created to provide general environmental withstand conditions for one or more of the above listed computer buses or interconnect standards, and electronic equipment in general.

While this document was specifically created for use with IEEE Computer Society bus standards, nothing herein is intended to restrict its use from other application, where applicable. A supplier and user may agree to more or less restrictive environmental specifications than those listed below. However, if their specifications are less restrictive than those listed herein, neither supplier nor user may claim conformance to this document.

3. Object

It is the object of this standard to provide a core specification for physical integrity and environmental performance levels for IEEE Computer Society micro computer circuit cards and components.

It is the responsibility of the system designer to evaluate the relationship between this card level environmental specification and the system level environmental specification for the enclosure which contains the cards. For example, in some applications, the cards are conduction cooled and a system level thermal "model" is required to determine the relationship between the card's heat sink and the system level cooling medium.

This standard shall be used in conjunction with the following list of documents which form a part of this standard to the extent specified herein.

1. IEC 68-2-1, Basic Environmental Testing Procedures, Part 2: Test A: Cold.
2. IEC 68-2-2, Basic Environmental Testing Procedures, Part 2: Test B: Dry Heat.
3. IEC 68-2-6, Basic Environmental Testing Procedures, Part 2: Test Fc and guidance: Vibration (sinusoidal).
4. IEC 68-2-10 Basic Environmental Testing Procedures, Part 2: Test J and guidance: Mould growth.

5. IEC 68-2-11 Basic Environmental Testing Procedures, Part 2: Test Ka: Salt mist.
6. IEC 68-2-13 Basic Environmental Testing Procedures, Part 2: Test M: Low air pressure.
7. IEC 68-2-14 Basic Environmental Testing Procedures, Part 2: Test N: Change of temperature.
8. IEC 68-2-27 Basic Environmental Testing Procedure, Part 2: Test Ea and guidance: Shock
9. IEC 68-2-30 Basic Environmental Testing Procedure, Part 2: Test Db and guidance, Damp heat, cyclic (12 + 12 hour cycle).
10. IEC 68-2-34 Basic Environmental Testing Procedures, Part 2, Test Fd: Random vibration wide band - General requirements.
11. IEC 68-2-35 Basic Environmental Testing Procedures, Part 2: Test Fda: Random vibration wide band - Reproducibility High.
12. IEC 68-2-36 Basic Environmental Testing Procedures, Part 2: Test Fdb: Random vibration wide band - Reproducibility Medium.
13. IEC 68-2-37 Basic Environmental Testing Procedures, Part 2: Test Fdc: Random vibration wide band - Reproducibility Low.
14. IEC 695-2-2 Fire Hazard Testing, Part 2: Test methods - Needle-flame test.
15. IEC 801-2, Electromagnetic Compatibility for Industrial-Process Measurement and Control Equipment, Part 2: Electrostatic discharge requirements.
16. ASTM D2863, Standard Method for Measuring the Minimum Oxygen Concentration to Support Candle-Like Combustion of Plastics (Oxygen Index).
17. MIL-M-28787 Modules, Standard Electronic, General specifications for
18. Federal Communications Commission (FCC) Rules, Part 15, Subpart J.

(Copies of the IEC standards may be purchased from the International Electrotechnical Commission, 3, Rue de Varembe, Geneva, Switzerland or from the American National Standards Institute, 1430 Broadway, New York, NY 10018, USA. The ASTM standard may be purchased from the American Society for Testing and Material, 1916 Race Street, Philadelphia, PA 19103-1187. Applications for copies of the MIL standard should be addressed to the Naval Publications and Forms Center, (ATTN: NPODS), 5801 Tabor Avenue, Philadelphia, PA 19120-5099.)

These standards shall be used in conjunction with the detail specification of the components to be tested. The detail specification prescribes the tests to be used, to ensure that the tested components conform to the performance levels listed herein.

4. Terminology

The terminology used in this standard is in accordance with that of the International Electrotechnical Vocabulary (IEV) and IEC 512-1. The following additional terms shall apply.

4.1 Performance Level

4.1.1 Performance Level 1 Environment primarily intended for aircraft, unsheltered marine (surface ship), and unsheltered shore applications subject to extreme vibration, shock, and temperature variations.

4.1.2 Performance Level 2 Environment primarily intended for sheltered marine and sheltered shore applications subject to harsh vibration, shock and temperature variations.

4.1.3 Performance Level 3 Environment primarily intended for sheltered applications subject to moderate vibration, shock, and temperature variations.

4.1.4 Performance Level 4 Environment primarily intended for thermally controlled, sheltered applications subject to moderate vibration and shock.

4.1.5 Performance Level 5 Environment primarily intended for controlled shelter applications subject to minimal vibration, shock or temperature variations.

4.2 Performance Level Qualification

It is the intent of this standard that for each defined performance level, all the parameters specified within that level are met in their entirety. In keeping with this intent, component boards, cards, and modules would, for example, be able to claim conformance to IEEE 1156.1 Performance Level 1 if they met all the test requirements.

Qualification to one performance level also qualifies the component to all less demanding levels, i.e., qualification to level three also carries automatic qualification to levels four and five. Similarly, if conformance to Level one is achieved, then conformance to all Levels is achieved. The exception to this definition is for the shock test magnitudes for levels one and two.

The intent of this document does not preclude one from mixing and matching requirements from among the performance levels defined in this standard. However, doing so would obligate one to state the requirement and the associated performance level of compliance. For example, one may claim conformance of a

circuit card as Operating Temperature to IEEE 1156.1 Performance Level 1 and Random Vibration to IEEE 1156.1 Performance Level 2.

Another facet of this document's intent is to standardize the values of environmental parameters and their test methods to assist systems engineers who must integrate components from various manufacturers. Deviating from the values specified by this standard shall be construed as using IEEE 1156.1 for guidance only and no conformation to this standard may be claimed.

4.3 Normal Operation

The unit operates within specifications, as per the individual component document. The particular parameters to be monitored shall be specified in the relevant component document. For example, electrical noise, mechanical strength, contact resistance, power level, frequency response, voltage breakdown, etc.

4.4 Maximum Power

All operating tests shall be performed at the maximum rated operating power in the specific test environment for that specific component.

4.5 Mounting

Mounting of any component undergoing testing is to be as the component would be typically mounted for its most common usage. The particular parameters to be monitored shall be specified in the relevant component document. For an assembly of components, i.e., rack, circuit board, connector, backplane, the system or subsystem manufacturer is responsible for the final testing.

4.6 Test Duration

Timing of the test duration, when applicable, begins after the item under test has achieved stability with regards to the test parameter.

4.7 Initial and Final Measurements

The measurements include all that are needed to verify that the component under test meets all of the component's detail specification before and after the test procedure for non-operating tests. The time when these detail specification tests are to be performed are described in the specific IEC environmental test. For operating tests the measurements must also be performed during the test at maximum rated power levels at the times suggested in the IEC environmental test. The particular parameters to be monitored shall be specified in the relevant component document. Records of the testing and results of the testing are to be retained by the component manufacturer for at least three years after the last date of component sale.

4.8 Relevant Specification

The IEC document cited herein refer to the "relevant specification". For the purpose of this standard, the relevant specification shall be IEEE 1156.1. Where IEEE 1156.1 does not offer complete information, then the detail specification for the component or module shall govern.

5. Climatic Category Characteristics

Climatic Categories are specified with three number as XX/YY/ZZ. The XX and YY represent the low and high storage temperature, respectively. The test is carried out as per IEC 68-2. The ZZ number represents the number of days that the component will be subjected to the Damp heat, steady state test, IEC 68-2-3-Ca. The climatic categories and performance levels are summarized in Table I.

Table I. Climatic Categories for the five performance levels.

Climatic Category	Temperature Range	Damp heat Steady State	Performance Levels				
			1	2	3	4	5
55/125/0	-55 $degree$C to + 125 $degree$C	0 days	X	X	-	-	-
40/65/0	-40 $degree$C to + 65 $degree$C	0 days	-	-	X	X	-
40/55/0	-40 $degree$C to + 55 $degree$C	0 days	-	-	-	-	X

6. Nonoperating Environmental Core Conditions

Computer modules/circuit cards and components shall withstand, without damage, the nonoperating environmental core conditions listed in TABLE II and described briefly below.

6.1 Low Temperature (non-operating,storage)

Low temperature withstand tests are to be carried out according to IEC 68-2-1-Ad to demonstrate compliance with this document. The tests are for 72 hours at the applicable temperatures as listed in TABLE II for the five performance levels.

6.2 High temperature (non-operating/storage)

High temperature withstand tests are to be carried out according to IEC 68-2-1-Bd to demonstrate compliance with this document. The tests are for 72 hours at the applicable temperatures as listed in TABLE II for the five performance levels.

6.3 Thermal Shock (non-operating/storage)

IEC 68-2-14-Na shall be performed to demonstrate compliance with the thermal shock requirement for the applicable performance level as shown in Table II. After three hours at the lower temperature the component under test is placed in the higher temperature environment with less than a three minute transition time. This

stress shall be repeated for five cycles. The temperature extremes are listed in TABLE II.

6.4 Humidity (non-operating/storage)

IEC 69-2-30-Db shall be performed to demonstrate compliance with the humidity requirement for the applicable performance level as shown in Table II.

6.5 Shock (non-operating/storage)

IEC 68-2-27-Ea shall be performed to demonstrate compliance with the shock requirement for the applicable performance level as shown in Table II.

The level of shock and time severity for a half sine wave pulse are listed in Table II for all the performance levels. Three pulses are to be applied in both directions of the three perpendicular axes for a total of 18 pulses. See Appendix A for the Shock and Vibration Fixture.

6.6 Atmospheric Corrosion (non-operating/storage)

IEC 68-2-11-Ka shall be performed to demonstrate compliance with the atmospheric corrosion requirement for the applicable performance levels as shown in Table II. The test exposure duration is 48 hours. (An alternate test is the ASTM Mixed Flowing Gas test with 10 days of exposure to 20 ppb chlorine, 100 ppb hydrogen sulfide, and 200 ppb of nitrogen dioxide at 70 % relative humidity and 30 degrees Celsius. This test is still being drafted by ASTM Committee B-4 and will be included in 1156.1 when it is available).

6.7 Fungus (non-operating/storage)

IEC 68-2-10-J shall be performed to demonstrate compliance with the fungus requirement for the applicable performance level as shown in Table II.

6.8 Flammability

IEC 695-2-2 shall be performed to demonstrate compliance with the flame requirement for the applicable performance level as shown in Table II.

A propane flame shall be used for the test and shall be applied to the lowest point on the component under test when it is held in its normal operating position. The length of the flame application time depends upon the component volume as follows: \$< 250 mm sup 3\$/5 sec; 250-500 \$mm sup 3\$/10 sec; 500-1750 \$mm sup 3\$/20 sec; or > 1750 \$mm sup 3\$/30 sec. Any flames present on the sample must self extinguish within 30 seconds after the removal of the needle flame.

In addition, all modules, including printed circuit boards and backplanes, shall have an oxygen index of 28 % or greater as determined by ASTM Standard D2863-77.

6.9 Electrostatic Discharge (ESD) (non-operating/storage)

IEC 801-2 shall be performed to demonstrate compliance with the electrostatic discharge (ESD) requirement for the applicable performance level as shown in Table II.

The component shall not be electrically damaged when contacted with a 30 kV test voltage on the exposed surfaces which are normally accessible to touch.

7. Operating Environmental Conditions

Computer modules/circuit cards and components shall withstand and maintain normal operation when subjected to the environmental withstand conditions and tests listed in TABLE III and described briefly

7.1 Low Temperature (operating)

IEC 68-2-1-Ad shall be performed to demonstrate compliance with the low temperature requirement for the applicable performance level as shown

7.2 High temperature (operating)

IEC 68-2-2-Bd shall be performed to demonstrate compliance with the high temperature requirement for the applicable performance level as shown in Table III.

For convection cooled modules see Appendix B.

7.3 Sinusoidal Vibration (operating)

IEC 68-2-6-Fc shall be performed to demonstrate compliance with the sinusoidal vibration requirement for the applicable performance level as shown in Table III.

Performance levels one and two shall be subjected to 20 sweeps of a 10-55 Hz sine wave and 2 sweeps of a 55-2000 sine wave with amplitudes and accelerations as listed in TABLE III. Performance levels three and four shall be subjected to 1 sweep of a 5-100 Hz sine wave with amplitudes and accelerations as listed in TABLE III. One sweep consists of one full cycle up and down the frequency scale in each of three mutually perpendicular axes of the equipment. See Appendix A for the Shock and Vibration Fixture.

7.4 Random Vibration (operating)

IEC 68-2-36-Fdb shall be performed to demonstrate compliance with the random vibration requirement for the applicable performance level as shown in Table III. The vibration time period is for 30 minutes on each of three mutually perpendicular axes over a frequency range of 20 to 2000 Hz. The acceleration spectral density is given in TABLE III. levels one and two. See Appendix A for the Shock and Vibration Fixture.

7.5 Shock (operating)

IEC 68-2-27 shall be performed to demonstrate compliance with the shock requirements for the applicable performance level as shown in Table III.

Three pulses in each direction on the three mutually perpendicular axes shall be applied. The half sine pulse g-forces and durations are given in TABLE III. See Appendix A for the Shock and Vibration Fixture.

7.6 Low Air Pressure (operating)

IEC 68-2-13 shall be performed to demonstrate compliance with the low air pressure requirement for the applicable performance level as shown in Table III.

7.7 Radiation (operating)

The Radiation Hardness Assurance Test of MIL-M-28787 shall be performed to demonstrate compliance with the radiation requirement for the applicable performance level as shown in Table III.

7.8 Electrostatic Discharge (ESD) (operating)

IEC 801-2 shall be performed to demonstrate compliance with the electrostatic discharge requirements for the applicable performance level as shown in Table III. Relative Humidity during the test shall be less than 50 % relative humidity.

7.9 Electromagnetic Induction (EMI) (operating)

All components shall comply with Federal Communications Commission Rules, Part 15, Subpart J for electromagnetic compatibility. If the components/modules have their own shielding, then compliance testing shall be performed with the shielding in place.

Table II. Nonoperating Core Conditions.

Test Parameter	IEC Test Publ.	Severity or conditions	Requirements Performance Level 1	2	3	4	5
Low Temp.	68-2-1-Ad	72 hrs	-55 °C to	-55 °C to	-40 °C to	-40 °C to	-40 °C to
High Temp.	68-2-2-Bd	72 hrs	+ 125 °C	+ 125 °C	+ 65 °C	+ 65 °C	+ 55 °C
Thermal Shock	68-2-14 Test Na	< 3 min	-55 °C to + 125 °C	-55 °C to + 85 °C	-55 °C to + 70 °C	-55 °C to + 70 °C	-40 °C to + 70 °C
Humidity B	68-2-30-Db	6 Cycles	25 °C to 55 °C 95%RH	25 °C to 55 °C 95%RH	25 °C to 55 °C 93%RH	25 °C to 55 °C 93%RH	25 °C to 55 °C 93%RH
Shock	68-2-27-Ea	6 ms	100g	100g	30g	30g	15g
Atmos. Corros.	68-2-11-Ka	48 hrs	X	X	X	-	-
	or ASTM	10 days	X	X	X	-	-
Fungus	68-2-10-J	28 days	X	X	X	-	-
Flame	695-2-2	28%		X	X	X	X
	ASTM-D2863	≥ 28 % O_2*	X	X	X	X	-
ESD	801-2	30kV/150pF	X	X	X	X	X

* All components shall have an oxygen index of at least 28 %.

Table III. Operating Core Conditions

Test Parameter	IEC Test Publ.	Severity or conditions	Requirements Performance Level 1	2	3	4	5
Low Temp.	68-2-1-Ad	16 hrs	-55 °C	-10 °C	+5 °C	+5 °C	+5 °C
High Temp.	68-2-2-Bd	16 hrs	95 °C	70 °C	55 °C	55 °C	55 °C
Sine Vib. A	68-2-6-Fc	10-55 Hz	1.5 mm/30g	1.5 mm/10g	-	-	-
Sine Vib. B	68-2-6-Fc	55-2000 Hz	1.5 mm/10g	1.5 mm/10g	-	-	-
Sine Vib. C	68-2-6-Fc	5-100 Hz	-	-	0.35 mm/5g	0.35 mm/5g	-
Random Vib.	68-2-36-Fdb	20-2000 Hz	$0.2g^2$/Hz	$0.1g^2$/Hz	-	-	-
Shock	68-2-27	18 pulses	30g/6 ms	50g/11 ms	15g/11 ms	15g/ 11ms	-
Low Air Pres.	68-2-13	16 hrs	1050/40 mbar	1050/550 mbar	1050/550 mbar	1050/700 mbar	1050/700 mbar
Radiation	OPTION						
ESD A	801-2	15kV/150pF	X	X	X	X	X
ESD B	801-2	15kV/15pF	-	-	-	X	-
ESD C	801-2	25kV/500pF	X	X	-	-	-
EMI	FCC,15J	Meet	X	X	X	X	X

APPENDIX A

Shock and Vibration Fixtures

A 1. Performance Levels One and Two.

A 1.1 Scope

The propose of the fixture is to afford a standard test vehicle for use by various agencies and companies to test modules. The fixture design shall offer common retention of the module and the mating connector to the module for testing the module with both rigid clamped boundaries and with system level module retainers. The fixture will contain self calibration to verify its integrity for repeated testing of modules. Refer to figure 1 for a concept of such a fixture.

A 1.2 Fixture Attribute

1. The fixture design shall be a normally closed approach so it requires opening to install a test sample (normally a module). This will greatly reduce the chance for operator error and the need for torquing bolts and other such variable operations.
2. The fixture will contain self calibration to ensure clamping forces to retain the test sample such as load transducers. See figure 2.
3. The fixture must be rugged enough to withstand acceleration loads up to 1000 Gs. This requirement is due to the potential imposed load generated by the test sample at resonant frequency.
4. The fixture resonance frequency shall be of the order of 4000 Hz.
5. The fixture is designed to provide both rigid clamped boundaries for test sample retension and provide for system level enclosure retainers (such as retainers that use a wedging action to produce clamping) for test sample retension.
6. The following addresses the rigid clamped condition. See Figure 3.
   1. The fixture must be designed to ensure rigid clamped boundaries, with no degradation with respect to clamping load, throughout vibration test frequency ranges (example: 10-2000 Hz) and maximum input acceleration levels (example: 30 Gs).
   2. The clamping force generated by each clamping edge (or Jaw) of the fixture should be designed to exceed the force created at 1000 Gs multiplied by the expected weight of the test sample. A suggested starting point is 1500 pounds.

   3. The fixture design will accommodate a range of module fin (or rib) thicknesses (presently 0.050 inches and 0.125 inches).
   4. The surface finish at the interface betwe-- module fin (or rib) and fixture jaw should be 64 microinches nominally.
   5. The hardness at the clamping jaw will be equivalent to a Rockwell hardness of 100 (RF) or greater.

7. The following addresses the application level testing employing module retainers.
   1. The two sides of the fixture which afford the clamping jaws shall contain a feature (such as a removable insert) to permit the module to be tested with retainers installed. The feature shall allow an opening the length of the sides of the fixture sufficient to accept the full length of the retainers. The feature will be sized to the opening as specified in the detail specification for proper operation of the module retainer.
   2. The jaws on the two sides of the fixture will be normally closed and the force exerted by the module retainer will be against the jaws. The normally closed force of the jaws will be a factor of 10 greater than the force of the retainers as a minimum.
   3. The fixture design will accommodate a range of module fin (or rib) thickness (presently 0.050 inches and 0.125 inches).
   4. The surface finish at the interface between module fin (or rib) and fixture jaw should be 64 microinches nominally.
8. The fixture design will not affect the electrical performance of the module's electronics i.e., no EMI fields, etc.
9. The maximum weight of the fixture shall not exceed 30 pounds.
10. The fixture will hold the test sample (module) parallel to the test table at a minimized height.

A 1.3 Fixture Verification

1. Each fixture will be qualified to clamping pressure and frequency response.
2. Standard test sample size(s) and weight(s) will be used for fixture calibration and verification testing. See Figure 5.

A 2. Performance Levels Three and Four.

A 2.1 Rigidly mount a card cage with backplane to a section of system frame by all the screws/bolts that would be used in a field installation.

A 2.2 Rigidly mount the above to a vibration table.

A 2.3 Load all slots of the card cage with the modules under test by inserting them into the card guides, fully engaging the backplane connectors, and fully engaging the faceplate latches.

A 2.4 Perform the shock and vibration tests as per IEEE 1156.1.

APPENDIX B

Thermal Testing of Forced Convection-Cooled Modules

B 1.Verification of a module's thermal design

Verification that a module operates within the temperature limits of the design can be done in an actual system or in a simulated "slot". To do the testing in an actual system, there must be a way of controlling the required test conditions to conform to IEC 68-2-2-Bd. The advantage of using an artificial test slot is that the test parameters can be independently adjusted so as to create the actual worst-case conditions. Direct measurement of the dependent parameters can then be made.

B 2. Test slot requirements

To create and use a valid test slot, the following environment needs to be utilized:

1. Power dissipation in adjacent slots within + /- 5 % of the test module's power dissipation.
2. Inlet air velocity, uniformity, and back-pressure in an empty slot as per the card cage detail specification.
3. Inlet air temperature as per Table III for the applicable performance level.
4. For modules used in card cages that are stacked, the test shall be performed in a vertical stack of card cages. Each card cage shall produce a similar heat load and the test module shall be in the top unit. An exception to this condition is allowed if the exception is noted in the conformance statement.
5. Operation of the unit under test.

B 3. Control of the variables and test performance

B 3.1 Operation of the unit under test. Typically the thermal profile of a module varies depending on the way in which the unit is being exercised. The module designer shall define the loads, clock speeds, dc voltage values, and other functions to simulate the worst-case conditions which the test is intended to reproduce and the the test set-up shall be capable of creating the stipulated conditions.

B 3.2 Power dissipation in adjacent slots. For air velocities in excess of 1.0 meters/sec, modules heights less than 300 mm, and separation between components on different modules in excess of 5 mm, it is reasonable to assume complete independence of thermal environments between adjacent modules, and the tester may discount any thermal coupling between adjacent slots. However, coupling between vertical slots is still to be taken into account.

B 3.3 Input air velocity, uniformity, and backpressure. The input air channel should provide the specified air velocity, both in average value and in uniformity, when ;the slot is empty. The insertion of a module into the test cavity increases the air-flow impedance of the cavity, which reduces air flow and raises the backpressure. The backpressure should be kept no higher than the lower specification limit of the enclosure. This may cause the air velocity to drop below the specification limit.

B 3.4 Input air temperature as per Table III.

B 3.5 Testing. The module/component shall be tested in the above slot to demonstrate compliance with the high temperature operating requirement from the applicable performance levels shown in Table III.

B 3.6 Guidance.

An enclosure of electronic equipment provides a predictable mechanical, electrical and thermal environment. It is the responsibility of the system designer to select environmental limits which satisfy the application and which provide sufficient degrees of freedom for the developers of modules or plug-in units. Minimum air velocity, and how it varies across the air inlet of the module slot and also as a function of card-cage loading shall be fully described. The range of backpressures possible, as well as the conditions that created them, shall also be specified.

Modules are designed to operate reliably in the given environment. With respect to thermal performance, it is the responsibility of the module designer to predict the maximum operating temperatures of each component, and from these numbers to predict the failure rate of each component and the MTBF of the module for all the environments which the enclosure can provide. The maximum operating temperature and cooling requirements shall be indicated in the documentation of the module.

Thermocouples or other sensors are used to obtain surface, case or heat sink temperatures during the test. Thermal resistances and known component power dissipation are then used to predict the internal temperatures of the individual components. The temperature rise of each component above ambient is a constant for any ambient temperature, so the maximum internal temperature of every component can be easily calculated. Various predictive formulas exist for calculating component failure rates as a function of their individual power dissipation and operating temperatures.

The module designer can calculate the expected MTBF of the module using the measurements and procedures above. It is the responsibility of the module designer to insure that the module is operated within the reliability limits that are the target of the design. Sufficient information concerning the reliability model employed should be provided by the developer to allow the user to make comparative

evaluations between implementations.

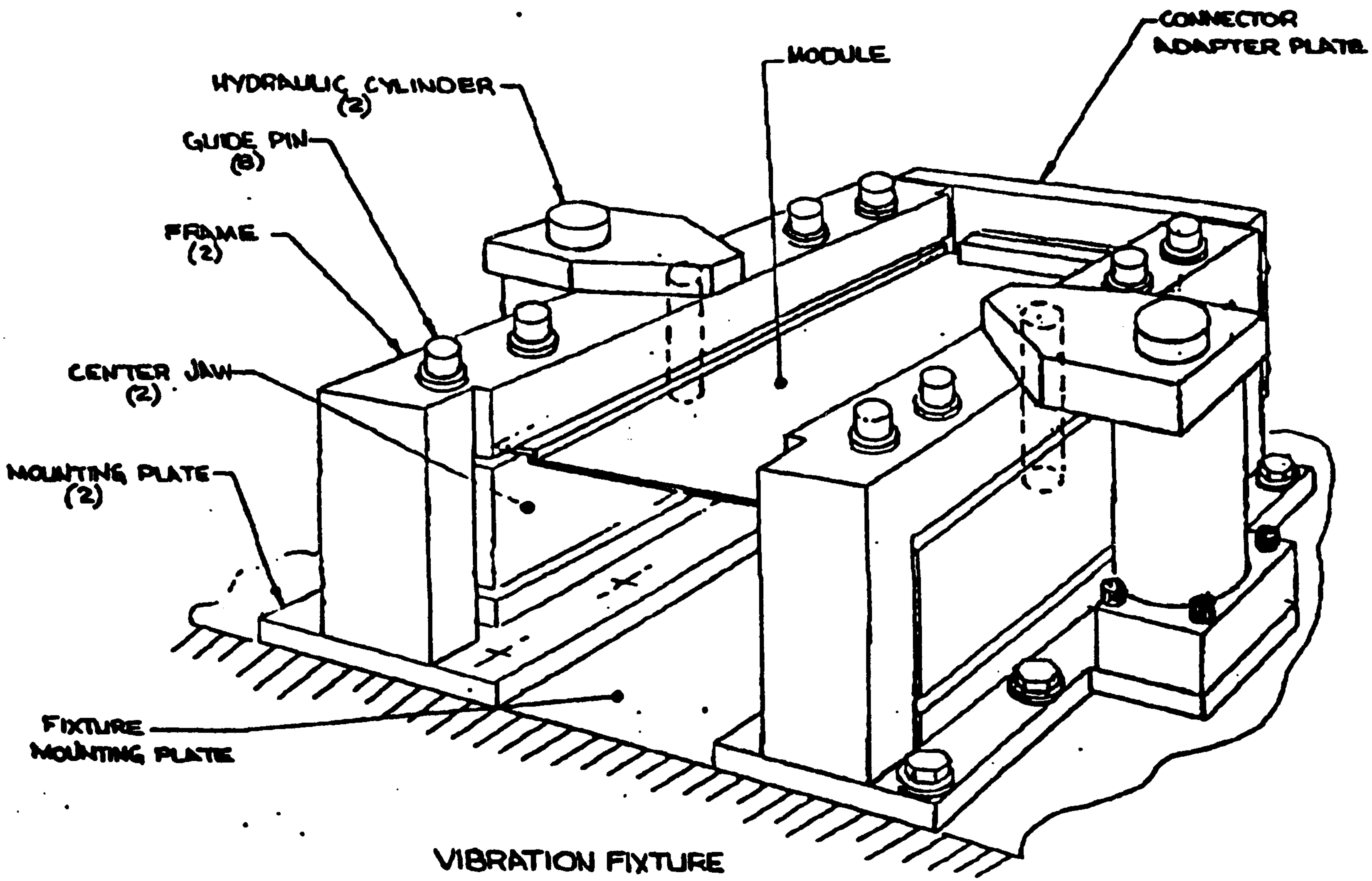
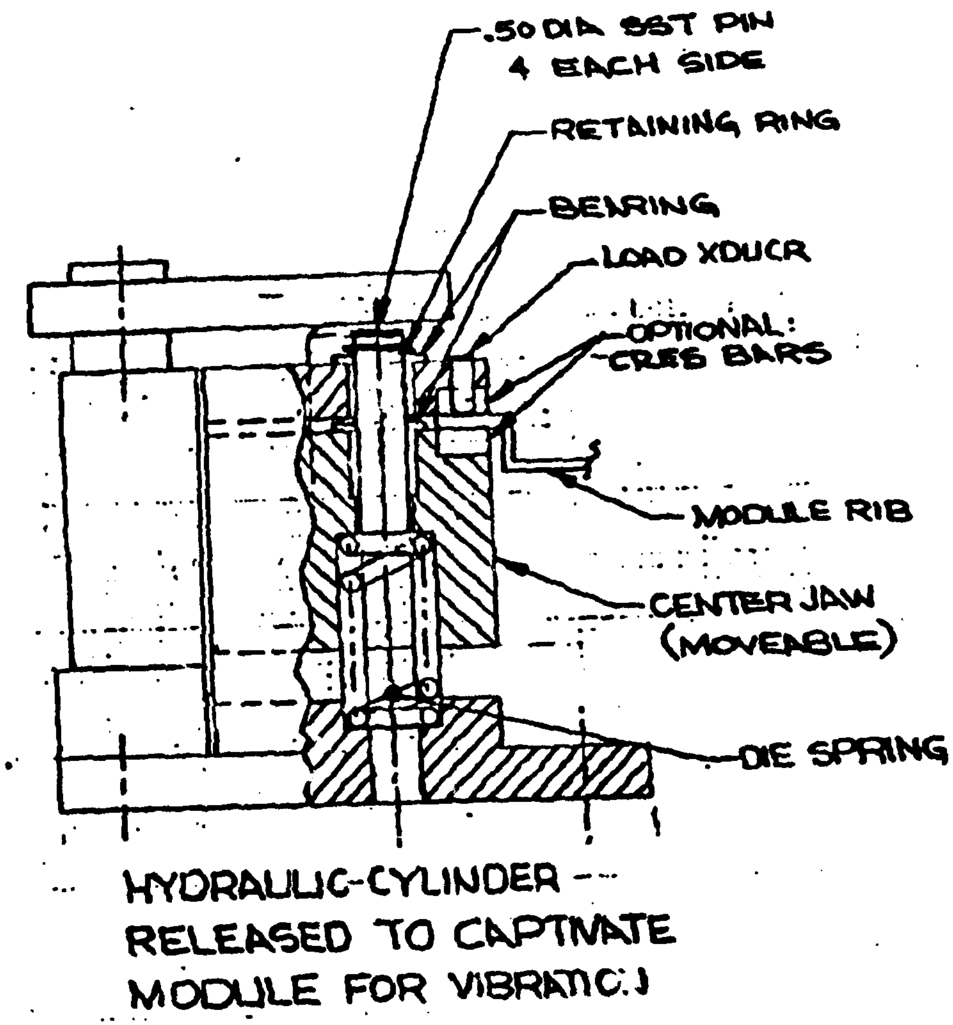

HYDRAULIC CYLINDER (2)
GUIDE PIN (8)
FRAME (2)
CENTER JAW (2)
MOUNTING PLATE (2)
FIXTURE MOUNTING PLATE
MODULE
CONNECTOR ADAPTER PLATE
VIBRATION FIXTURE

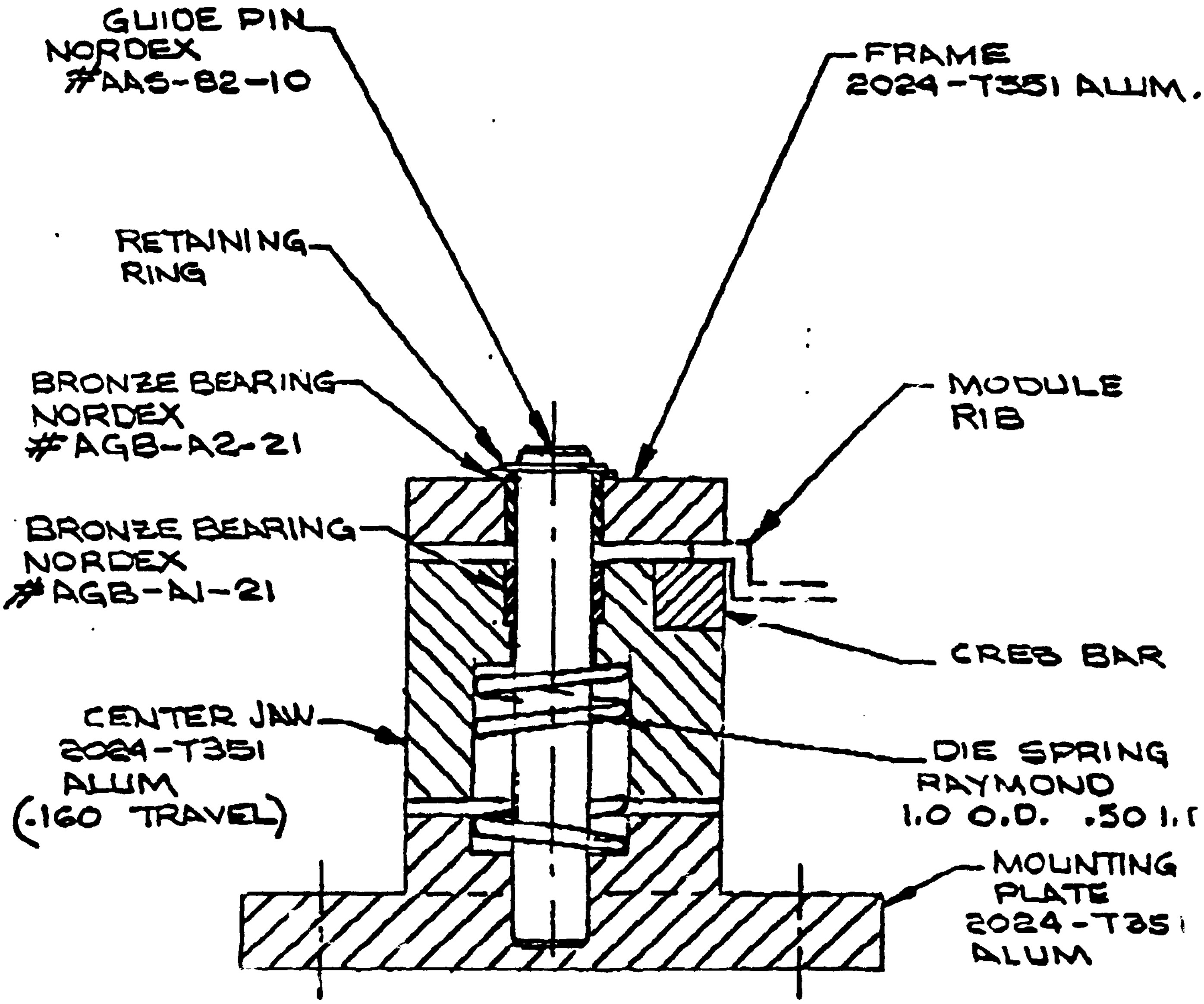
FIGURE 1



VIBRATION FIXTURE

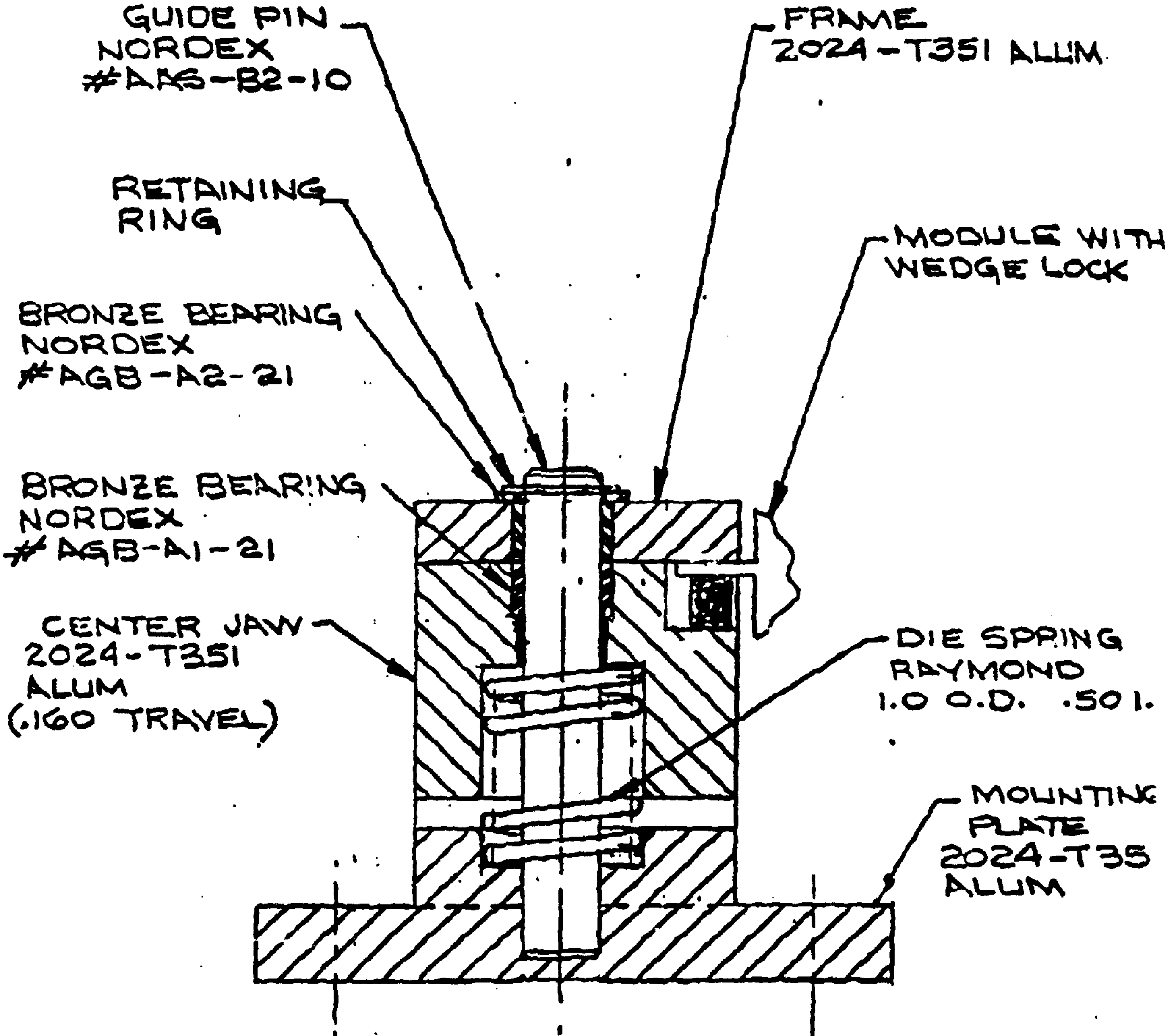
FIGURE 2

FIGURE 3



MODULE VIBRATION FIXTURE

FIGURE [illegible]



MODULE VIBRATION
FIXTURE

STANDARD TEST MODULE:

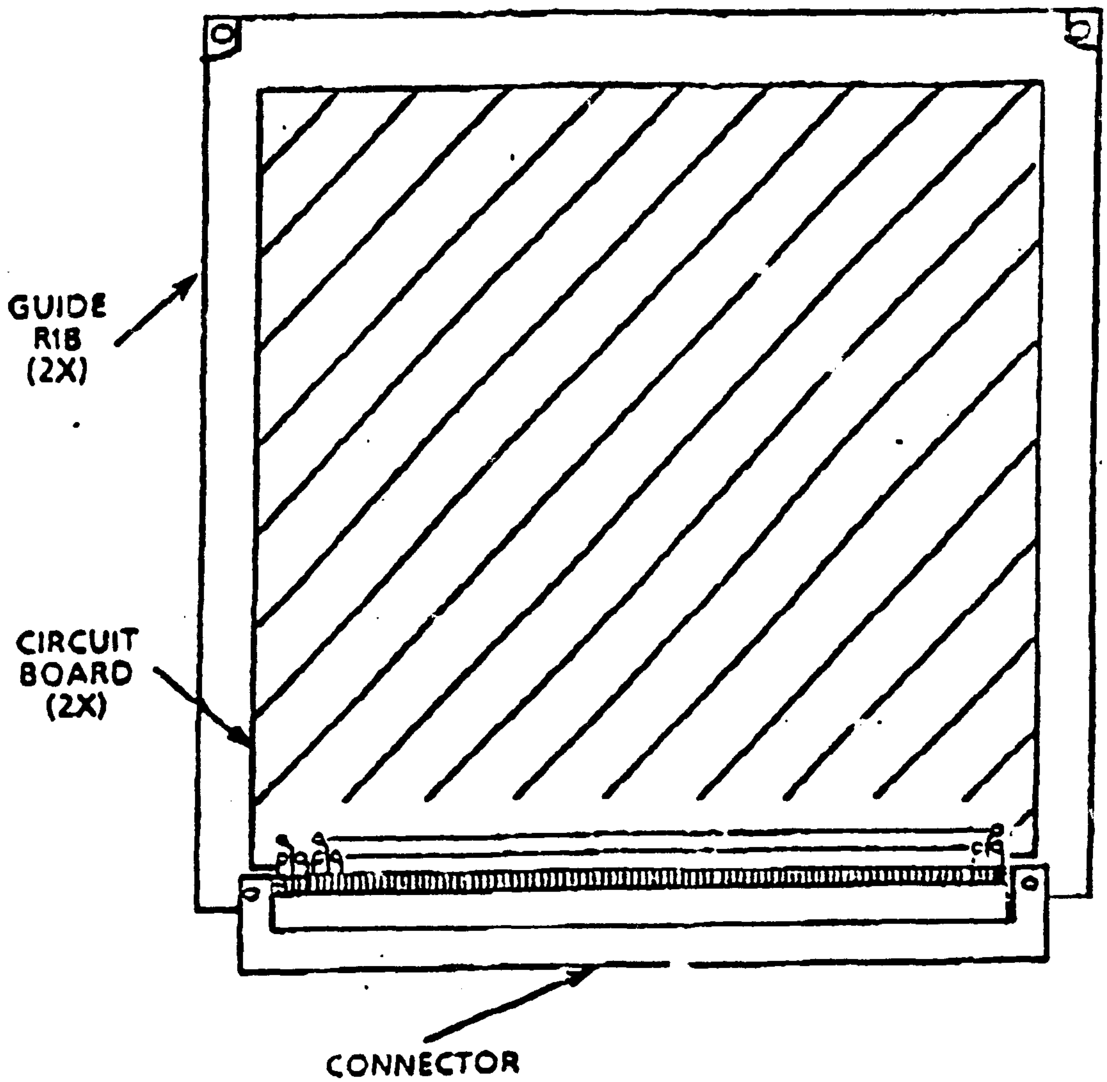


FIGURE 5